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Study of THD in Different CHB MLIs Controlled With Unipolar and Bipolar Carrier Based Modulation Techniques

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ABSTRACT

Multi-level inverters (MLIs) are gaining popularity due to their inherent advantages like better harmonic distortion, ability of producing higher magnitudes of AC voltages. As these converters uses many cascaded connection of many small units the switches used in devices are subjected to less voltage stresses. H-bridge based multilevel inverter can increase the number of output voltage levels by adding switch components and DC input voltage sources. If it employs seven switches and three DC sources, the number of output voltage levels becomes seven. Although its THD characteristics are improved, it needs output filter to meet general output voltage THD requirement, i.e., 5 % below. By adding PWM switching schemes to the operation of the prior H-bridge switches, it can synthesize more sinusoidal waveform. By this simple alteration in the switching scheme, it can improve the output voltage THD requirement. To verify the high performance of the proposed switching scheme, Unipolar, Bipolar, Third harmonic based Pulse width modulation schemes are considered for analysis and computer-aided simulations are conducted using MATLAB.

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I. INTRODUCTION

Recently multilevel inverters have become more attractive to researchers and industrial companies due to fast developing of high power devices and related control techniques (Khajehoddin et al., 2007). The recent advancement in power electronics has initiated to improve the level of inverter to cater to the need of medium voltage high power applications without transformer (KjaerefoJ.,2005).

The three common topologies for multilevel inverters are as follows: Diode clamped (neutral clamped), capacitor clamped (flying capacitors), cascaded H-bndge inverter but the one considered in this study is the cascaded H-bridge multilevel inverter. These converter topologies can generate high-quality voltage waveforms with power semiconductor switches operating at a frequency near the fundamental. It significantly reduces the harmonics problem with reduced voltage stress across the switch (Kjaerefa, 2005). The cascaded H-bridge multilevel inverter topology has many advantages not only in terms of its simple structure but also allows the use of a single dc source as the first dc source with the remaining (n-1) dc sources being capacitors (Seyezhai and Mathur, 2010). The voltage regulation of the capacitor is the key issue and this is achieved by the switching state redundancy of the proposed modulation strategy. This scheme also provides the ability to produce higher voltages at higher speeds with low switching losses and high conversion efficiency. The cascaded multilevel control method is very easy when compared to other multilevel inverter because it doesn't require any clamping diode and flying capacitor (Mafhurm and Seyezhai, 2008).

The diode-clamped inverter (neutral-point clamped), capacitor-clamped (flying capacitor) requiring only one dc source and the cascaded bridge inverter requiring separate dc source. The latter characteristic which is a drawback when a single dc source is available becomes a very attractive feature in the case of PV Systems because solar cells can be assembled in a number of separate generators. In this way, they satisfy the requirements of the CHB-MLI, obtaining additional advantages such as a possible elimination of the dc/dc booster (needed in order to adapt voltage levels), a significant reduction of the power drops caused by sun darkening (usually, it influences only a fraction of the overall PV field) and therefore, a potential increase of efficiency and reliability (Aghdam et al, 2008).

Performance of the multilevel inverter (such as THD) is mainly decided by the modulation strategies. For the cascaded multilevel inverter there are several well known pulse width modulation strategies such as space vector pwm, sinusoidal pwm, selective harmonics elimination and multicarrier pwm (Tolbert et al, 1999). Compared to the conventional method, the proposed method is subjected to a new modulation scheme adopting the multicarrier pulse width modulation concept which uses multiple modulating signals with a single carrier reduces the total harmonic distortion (Rodriguez etal., 2002).

This research study deals with harmonic analysis in 5, 7, 9 and 11 levels by considering up to 23rd harmonics of single phase cascaded H-bridge multilevel inverter employing multicarrier pulse width modulation technique for grid connected photovoltaic system. The effect of cascaded h-bridge multilevel inverter topology and change in PV input parameters irradiation and temperature on the performance parameters has been analyzed.

II. CASCADED H-BRIDGE MULTI-LEVEL INVERTER

Multi-level inverters have emerged recently as very important role in the area of high power and medium voltage applications. The multi-level inverters are, (i) diode clamped multi-level inverters (ii)flying capacitor multi-level inverter(iii)cascaded H-bridge multi-level inverter, the cascaded H-bridge multi-level inverter have some disadvantages compared to other topologies, because it have the full H-bridges that improving the level of the voltages. Same numbers of components are sufficient for each level. In sinusoidal pulse width modulation, sine wave is compared with the carrier wave, the pulses are produced. Then that produces pulses given to the multi-level inverters, in SVPWM modulating waves are compared with the carrier wave that produced pulses also given to the multi-level inverters. Carrier based schemes are used for multi-level inverters. Number of carriers are depends on the levels of the multi-level inverters. For five level inverts four carriers are used.

In cascaded H-bridge multi-level inverter uses cascaded full bridge inverters with separate DC sources, number of devices used in the circuit are less. Using of H-bridges multilevel inverter increases the voltage level of the inverter. The fig 1 shows cascaded H-bridge based multi-level inverter. This requires less no of components, same amount of components are sufficient in every voltage level. For different voltage level the operation of switching sequence will be following in the table1, when the battery has 2Vdc voltage. For zero voltage the S1, S3, S5, S7 switches get ON. For Vdc Voltage S2 S6 S8 S2 switches will be ON. For 2Vdc voltage S1, S6, S5, S2 switches will be ON, For -2Vdc voltage S3,S8,S7,S4 switches will be ON, For -Vdc voltage S3,S7,S5,S4 switches will be ON.

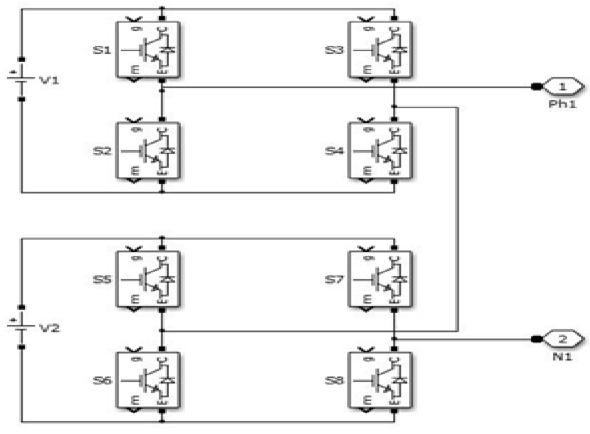

Fig 1: Cascaded H Bridge based Multilevel Inverter

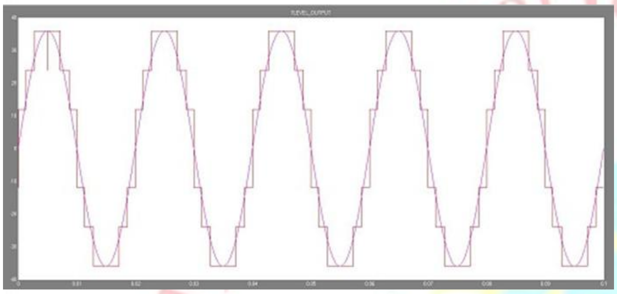

Fig 2: Output of a Seven Level Inverter

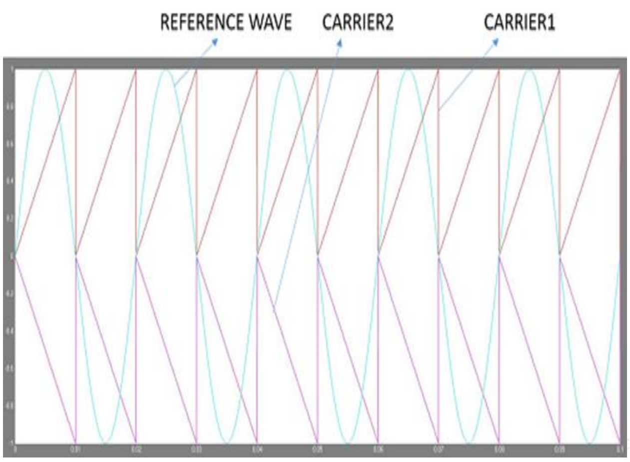

Fig 4: Unipolar Switching signals

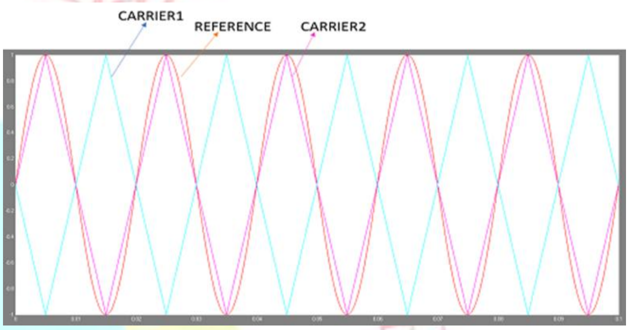

Fig 5: Bipolar switching sequence generation

III. SINUSOIDAL PULSE WIDTH MODULATION

In the sinusoidal pulse width modulation, the reference wave is the sine wave. That is compared with the carrier triangular Wave, the pulses are produced. That is given to the inverter. .The sine wave is greater than the carrier wave the top switches are ON. Otherwise the bottom switches are ON.

In this paper Bipolar and Unipolar switching schemes with sinusoidal and third harmonic based sinusoidal switching schemes are used for generation of switching sequences for inverter switching. In bipolar switching scheme carrier signal have both positive and negative polarities whereas in unipolar switching scheme carrier signal have only one polarity that is either in positive or in negative. Different carrier and modulating signals are shown in fig 3 to 7.

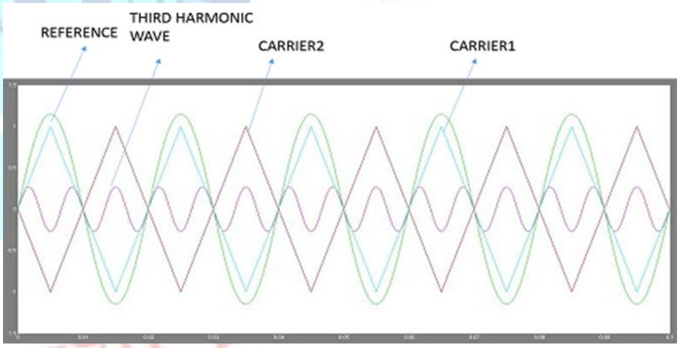

Fig 6: bipolar switching sequence With 3rd Harmonic modulating signal.

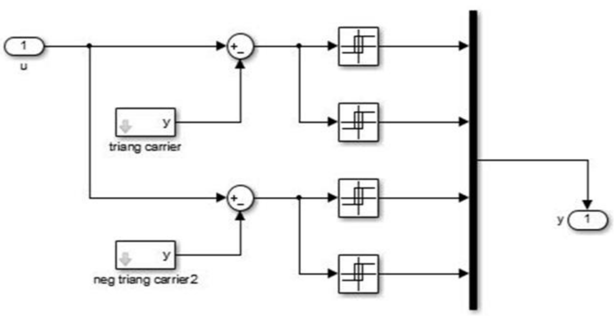

Fig 3: Unipolar switching sequence generation

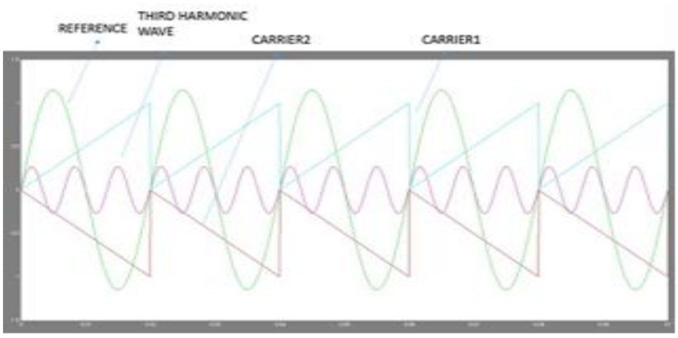

Fig 7: unipolar switching scheme with 3rd Harmonic Signals

IV. MODEL SIMULATION & RESULTS

Different control schemes proposed in chapter III are applied to a 3-Level, 5-Level, 7-Level, 9-Level and 11-inverters for identification of switching scheme that gives minimum harmonic distortion. MATLAB simulations are done for different indexes. Observations made on the different converter circuits are presented in table – I and Table – II for modulation index vales 0.9 and 1.0 respectively.

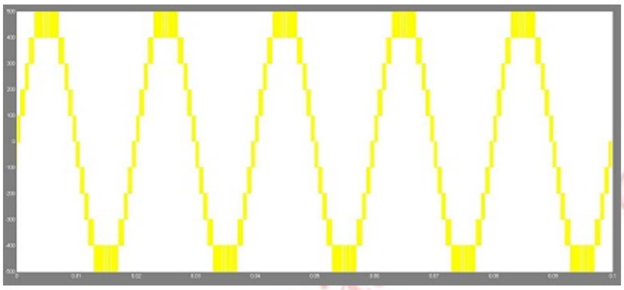

Fig 8: Voltage of 11 level 3 Phase CHB across load terminals with Bipolar SPWM switching When mIndex = 1

Name of Control Technique	Level of Inverter output voltage	% of Output Voltage	% THD
Unipolar Carrier Based SPWM	3	90.11	63.33
	5	90.11	63.33
	7	90.11	63.33
	9	90.11	63.33
	11	90.11	63.33
Bipolar Carrier Based SPWM	3	90.07	64.11
	5	90.04	33.32
	7	90.05	22.41
	9	90.06	16.68
	11	89.99	13.21
Unipolar Carried Based Third Harmonic SPWM	3	103.6	54.78
	5	103.6	54.78
	7	103.6	54.78
	9	103.6	54.78
	11	103.6	54.78
Bipolar Carrier Based Third Harmonic SPWM	3	103.6	56.71
	5	103.5	37.76
	7	103.5	31.13
	9	103.5	27.9
	11	103.6	25.96

Table I: Observation table for mIndex = 0.9

Name of Control Technique	Level of Inverter output voltage	% of Output Voltage	% THD
Unipolar Carrier Based SPWM	3	100.1	51.11
	5	100.1	51.11
	7	100.1	51.11
	9	100.1	51.11
	11	100.1	51.11
Bipolar Carrier Based SPWM	3	99.99	52.1
	5	99.98	26.94
	7	100	18.08
	9	99.98	13.75
	11	99.98	11.08
Unipolar Carried Based Third Harmonic SPWM	3	114.5	41.73
	5	114.5	41.73
	7	114.5	41.73
	9	114.5	41.73
	11	114.5	41.73
Bipolar Carrier Based Third Harmonic SPWM	3	114.7	43.9
	5	114.7	31.21
	7	114.8	27.62
	9	114.7	26.1
	11	114.8	25.19

Table – II: Observation table for mIndex = 1

V. CONCLUSION

It is observed that irrespective of the level of the circuit Bipolar Sinusoidal Pulse Width Modulation Scheme gives rise to least magnitude of Total Harmonic Distortion when compared with the other proposed switching schemes. Unipolar switching scheme with Fundamental and third harmonic based modulating signals give more total harmonic distortion. Whereas bipolar swathing scheme with third harmonic modulating signal gives 14% higher output voltage compared to the output voltage magnitude of other switching schemes but total harmonic distortion is more compared to Bipolar Sinusoidal Pulse Width Modulation Scheme.

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